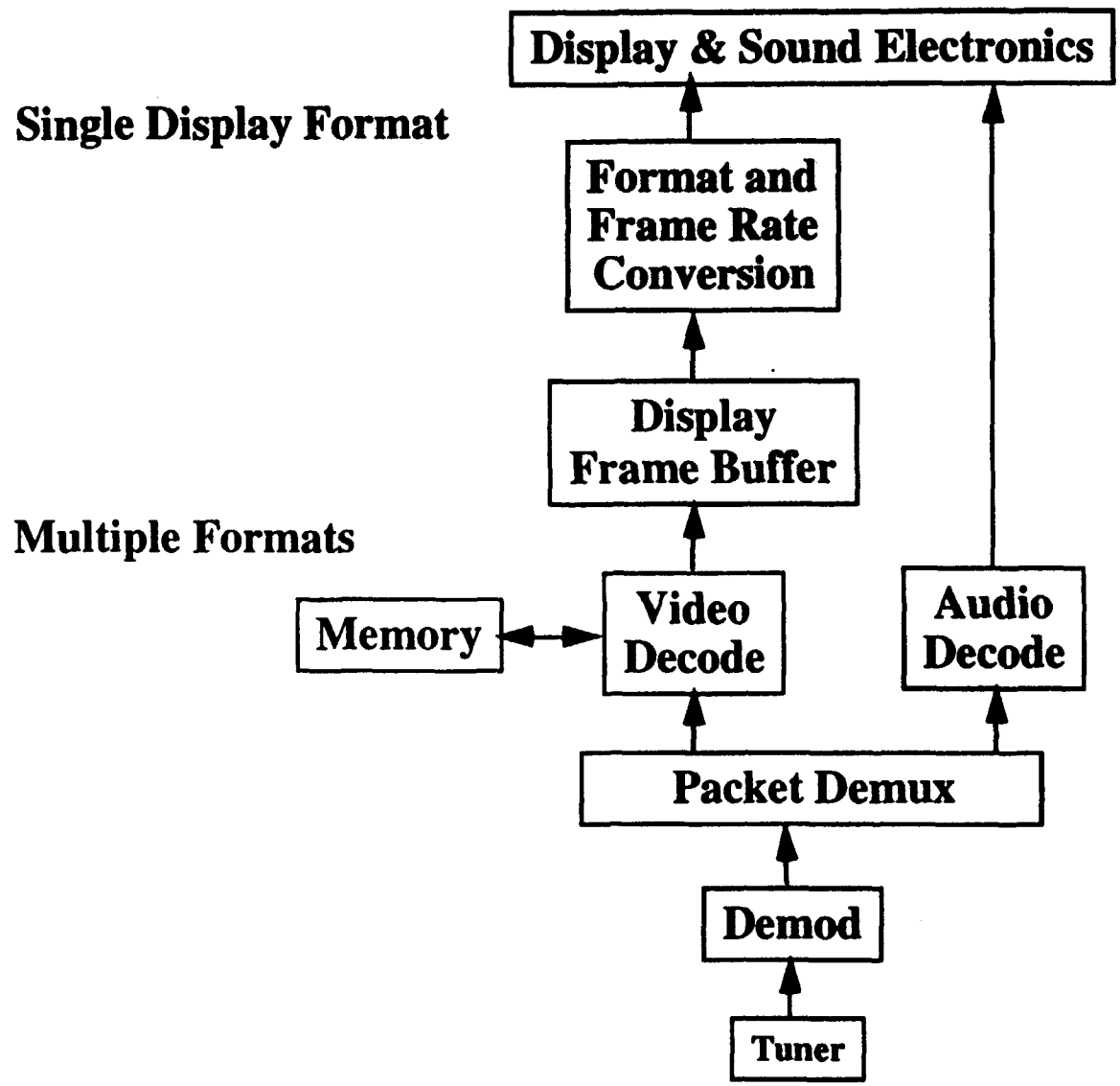
GA Picture Formats

Spatial	Temporal	
"X" x "1000"	23.97 / 24	progressive
	29.97 / 30	progressive
	59.94 / 60	interlaced
1280 x 720	23.97 / 24	progressive
	29.97 / 30	progressive
	59.94 / 60	progressive

- The minimum GA HDTV receiver must decode and present on its display all of these transmitted formats
- The display itself is a receiver implementation option

A Receiver Architecture Example



Receiver Format Conversions

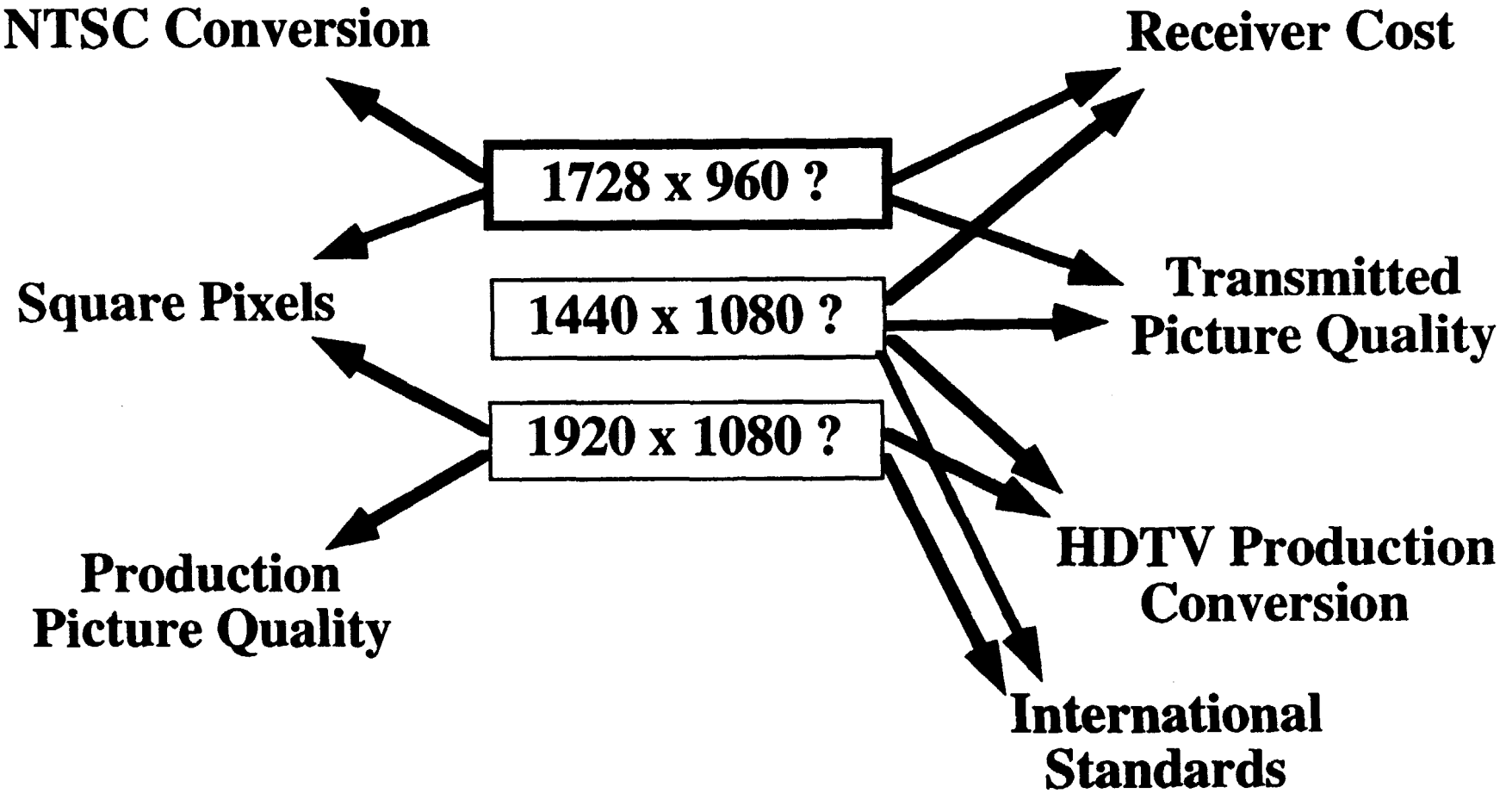
Transmitted Format			Conversions to 720 Line Progressive Display
Spatial	Temporal		
"X" x "1000"	23.97 / 24	progressive	3:2 frame repeat and 3:2 interpolation
	29.97 / 30	progressive	2:1 frame repeat and 3:2 interpolation
	59.94 / 60	interlaced	2:3 interpolation/de-interlace
1280 x 720	23.97 / 24	progressive	3:2 frame repeat
	29.97 / 30	progressive	2:1 frame repeat
	59.94 / 60	progressive	none

Receiver Format Conversions

Transmitted Format			Conversions to 1000 Line Interlaced Display
Spatial	Temporal		
"X" x "1000"	23.97 / 24	progressive	3:2 frame repeat and interlace
	29.97 / 30	progressive	2:1 frame repeat and interlace
	59.94 / 60	interlaced	none
1280 x 720	23.97 / 24	progressive	3:2 frame repeat and 3:2 interpolation
	29.97 / 30	progressive	2:1 frame repeat and 3:2 interpolation
	59.94 / 60	progressive	3:2 interpolation

"X" x "1000" Format Influences

...the GA and ACATS have not yet resolved this issue...



Film

- **Film interoperability is of great economic importance**
  - **about 80% of prime time TV is produced on film**
- **The GA HDTV system has been designed to directly deliver "electronic film" formats in progressive scan**
- **"X" x "1000" and 1280 x 720 at 24 fps**
  - **24 fps frame rate identical to film simplifies transcoding**
  - **progressive scan and square pixels**
  - **conversion to display rate performed in receiver is an economical approach because compression already requires frame memory in receivers**
- **Display frame rate is a receiver option, for example:**
  - **3:2 conversion to a 60 fps display**
  - **3:1 conversion to a 72 fps display**
  - **2:1 conversion to a 48 fps light valve projection display?**

NTSC

- **NTSC interoperability is of great economic importance**
  - **simulcast requires broadcast conversion and dual standard receivers over the lifetime of NTSC**

- **1728 x 960 (1440 x 1080?) formats**
  - **initial 59.94 Hz mode identical to NTSC simplifies transcoding and dual standard receivers**
  - **2:1 (9:4) vertical relation to NTSC simplifies transcoding and HDTV/NTSC receivers**
  - **2H deflection for lowest cost receivers**

- **1280 x 720 formats**
  - **initial 59.94 Hz mode identical to NTSC simplifies transcoding and dual standard receivers**
  - **3:2 vertical relation to NTSC simplifies transcoding and dual standard receivers**
  - **3H deflection for low cost progressive scan receivers**

HDTV Production

- **Production/transmission interoperability is of great economic importance**
- **U.S. HDTV production standard will most likely be 1920 x 1080 60 Hz interlaced, with a later step to progressive**
- **1440 x 1080 (1728 x 960?) formats**
  - **initial 59.94 Hz mode identical to NTSC simplifies transcoding and dual standard receivers**
  - **9:4 (2:1) vertical relation to NTSC**
  - **3:2 vertical relation to 720 line format**
  - **3:4 (≈8:9) horizontal relation to 1920 production format**
  - **≈2H deflection for low cost dual standard receivers**

30 fps Film

- The 30 fps "electronic film" formats provide for higher frame rate progressive capture than "conventional" film

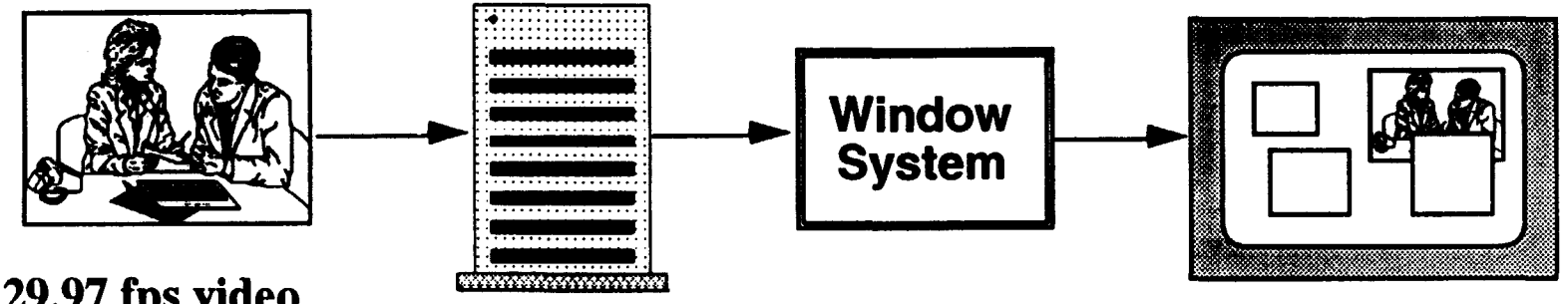
- "X" x "1000" and 1280 x 720 at 30 fps
  - 30 fps frame rate reduces motion artifacts
  - progressive scan and square pixels
  - conversion to display rate performed in receiver
  - this is an economical approach because compression already requires frame memory in receivers

- Display frame rate is a receiver option, for example:
  - 2:1 conversion to a 60 fps display
  - 12:5 conversion to a 72 fps display
  - 3:1 conversion to a 90 fps display

Computer Architecture

...windowing systems inherently require picture format conversions...

- Computer displays are progressive scan, >60 fps
- No single display standard in the computer industry
- Key architecture principle: window system manages display



- Window system and supporting hardware will perform:
  - frame rate conversion
  - image scaling (and format conversion)
  - deinterlacing (when needed)

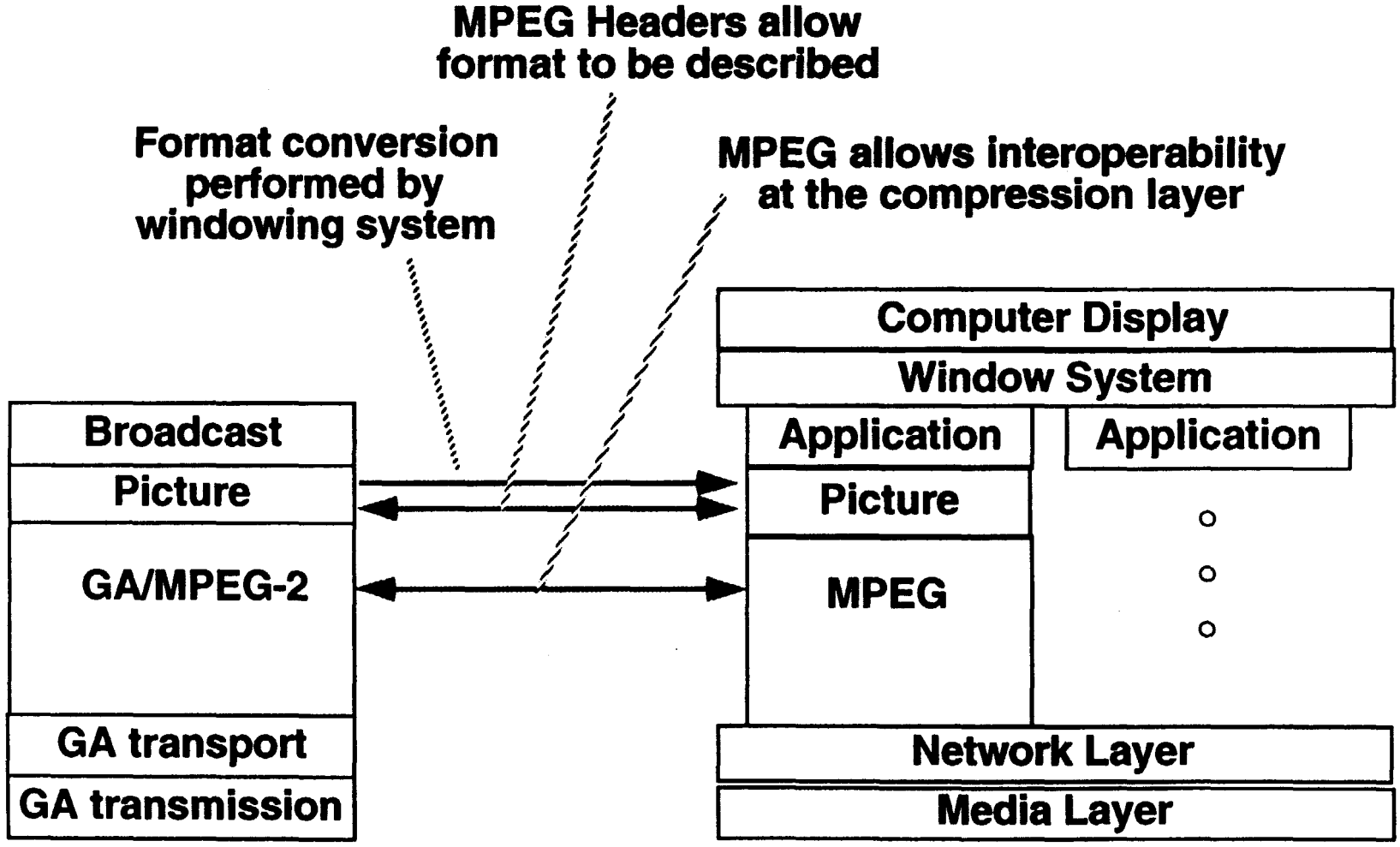
Computer Interoperability

- **Computer interoperability was a key design consideration**
  - **square pixel and progressive scan formats**

- **Advanced windowing systems will perform picture scaling in order to resize image windows**
  - **can also perform picture format conversions and deinterlacing as required (necessary to deal with NTSC)**
  - **many approaches and quality levels are possible**

- **Interoperability at the compression layer is of much greater importance than simple picture layer issues**
  - **significantly lower I/O bandwidth**
  - **compressed video will be used on storage media, networks, etc.**

Computer Interoperability



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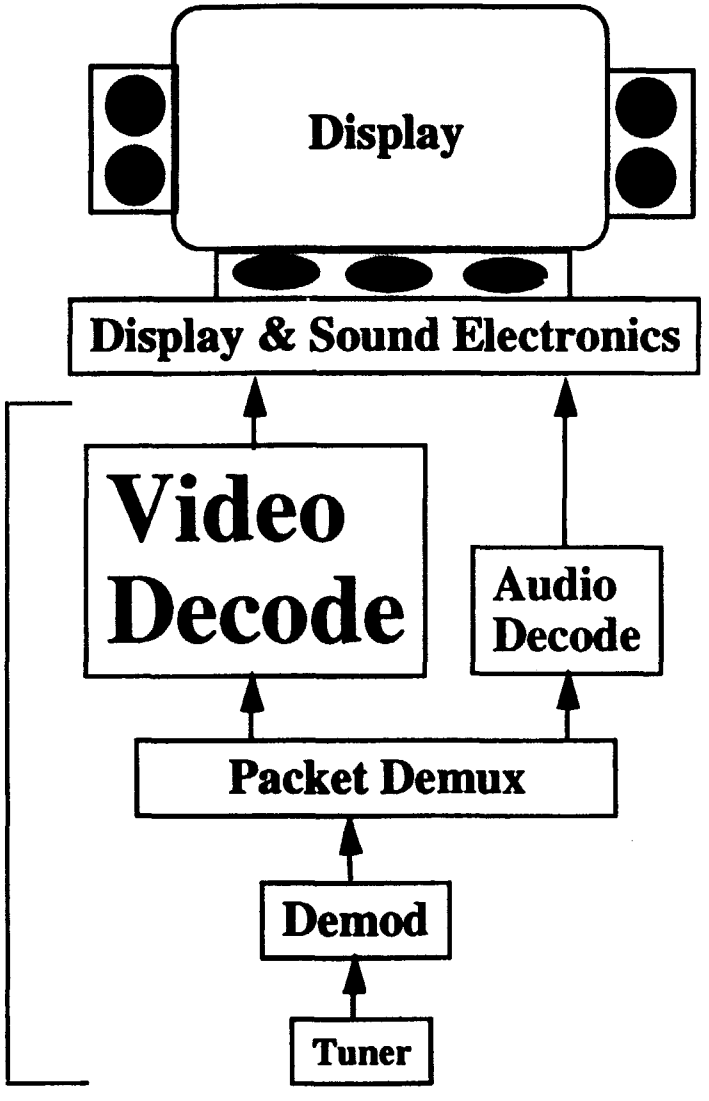
Low Cost Considerations

A Receiver Parts Cost Perspective

34"Direct View	56"Projection
$1,006	**$1,522**
Display: $763	Display: $1,226
Speakers: $ 30	Speakers: $ 30
Decoders: $127	Decoders: $127
Cabinet: $ 90	Cabinet: $140



Source: AD-HDTV data from SS-WP3 Final Report

Low Cost Receiver

- **Display and associated circuitry are the largest cost elements of a receiver**
  - **The ability to produce low-cost receivers is influenced more by displays than by electronics**

- **It is important to enable a broad spectrum of products with differing quality and capability vs. cost**
  - **Lowest cost receivers can use a 1000 line interlaced display with 2H deflection**
  - **Other receivers can use a 720 line progressive display with 3H deflection**
  - **High end receivers can use a 1000 line progressive display with 4H deflection**

- **It is important to encourage a migration to higher quality and capability products in the future**
  - **Enabled by the GA layered system architecture**
  - **Interfaces at each layer can appear over time**

Low Cost VCR

- **HDTV recording will directly record the GA compressed bit stream**
- **VCR capability was demonstrated by all predecessor systems**
- **VCR cost is dominated by the required data rate**
- **Digital VCR products for NTSC will likely preceed HDTV into the marketplace, and will form the basis for HD-VCRs**
- **The data rate used in intra-field compressed NTSC VCRs will be ≈50 Mbps, with a 25 Mbps long-play mode**
- **THEREFORE: VCRs for HDTV at 18 Mbps will leverage an existing production base to achieve low cost**

Extensibility and Migration Plan

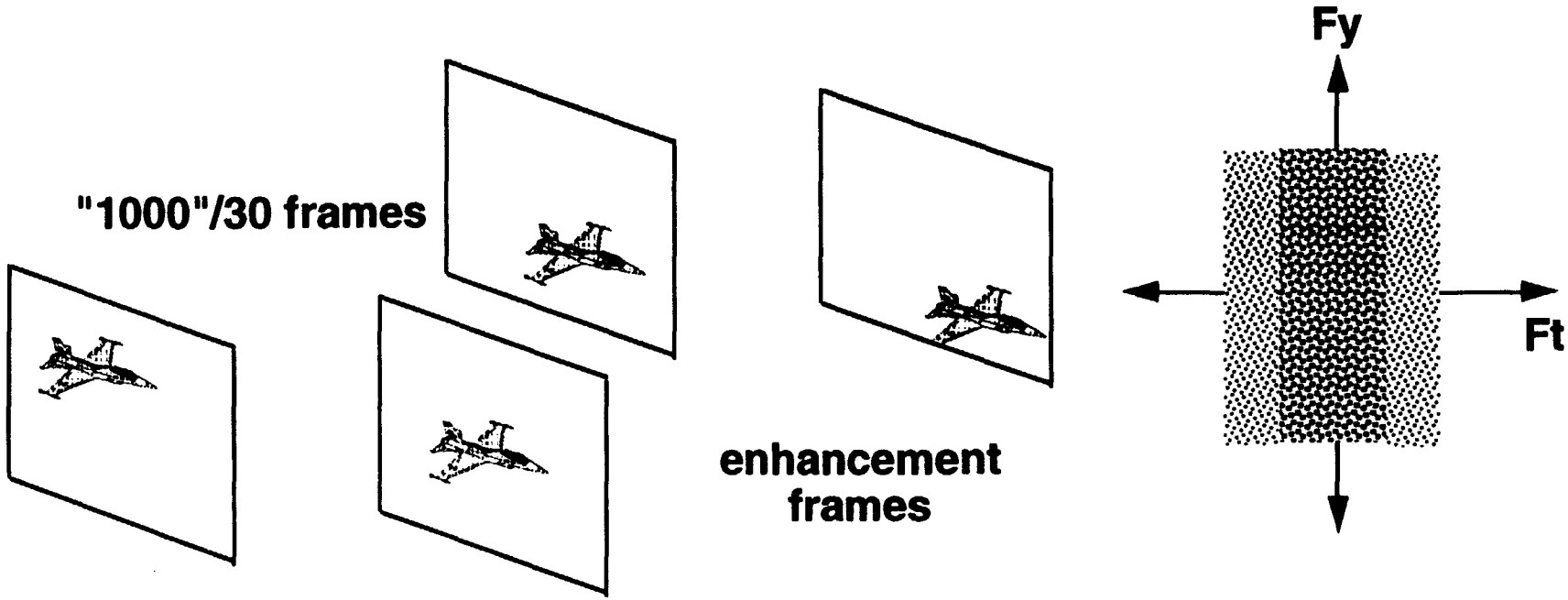
Migration to 60 Hz

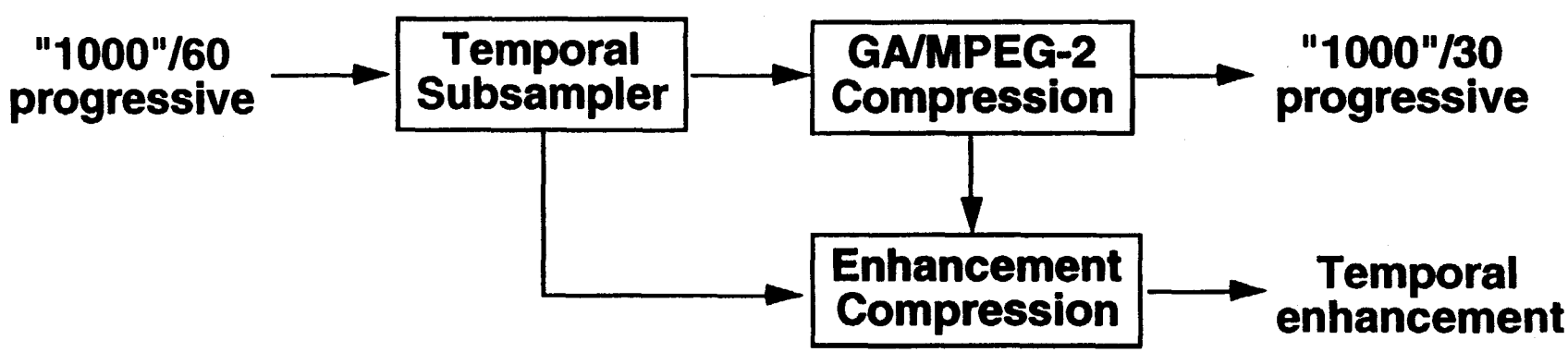
- **Today's production and broadcast is all based on 59.94 Hz**
- **During the introduction of HDTV, a 59.94 rate allows most economical transcoding between NTSC and HDTV**
- **Over the long term, 60 Hz has many advantages, but it requires 1001/1000 temporal rate conversion with NTSC**
- **The Grand Alliance system provides both 60 and 59.94 transmission, so that broadcasters can "throw the switch"when justified by the mix of HDTV/film vs. NTSC source material**

Extensibility and Migration Plan

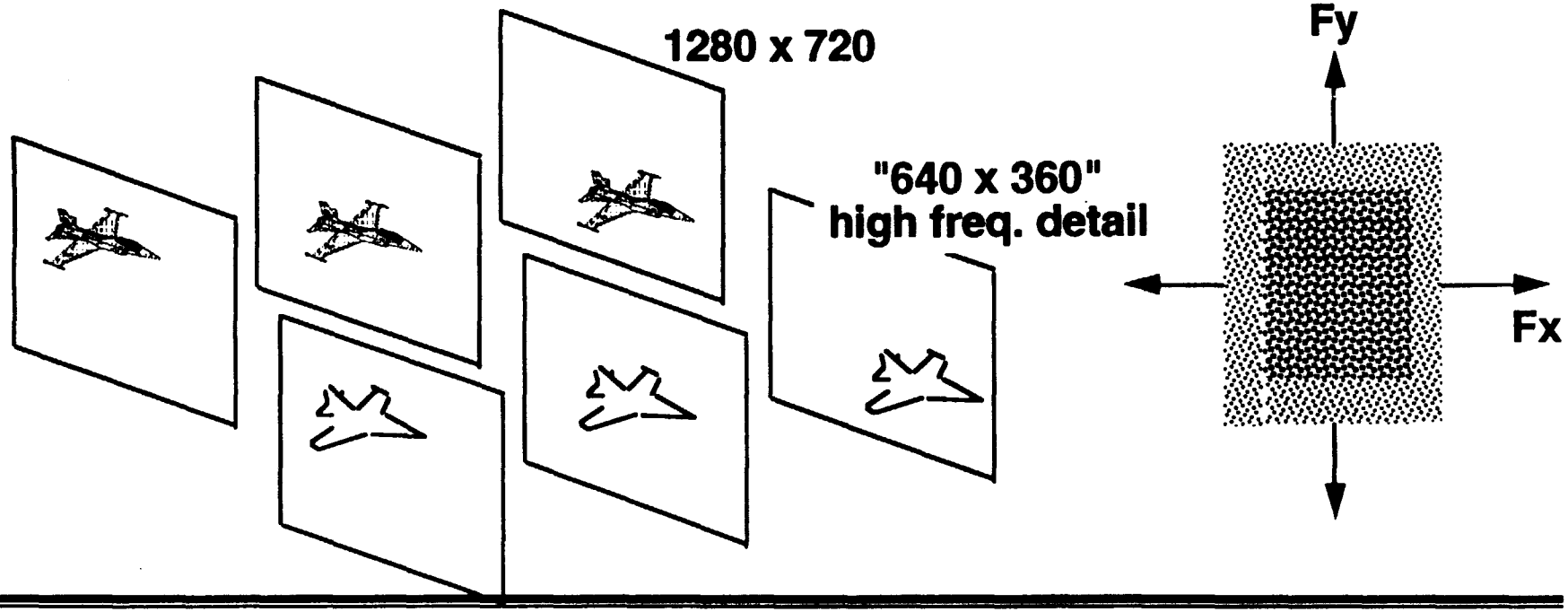
- **Long term goal is "1000" line progressive scan at 60 Hz**
- **The GA believes that this goal can be achieved by sending enhancement data that will complement the initial HDTV data stream**
  - **coding efficiency will be an important issue**
- **It is feasible to base enhancement coding on any or all of the initial transmission formats**
- **Packet-level extensibility is a fundamental enabler of this principle**
- **Transmission capacity for enhancement data must be created, possibly using more power or an additional channel as NTSC stations go out of service**

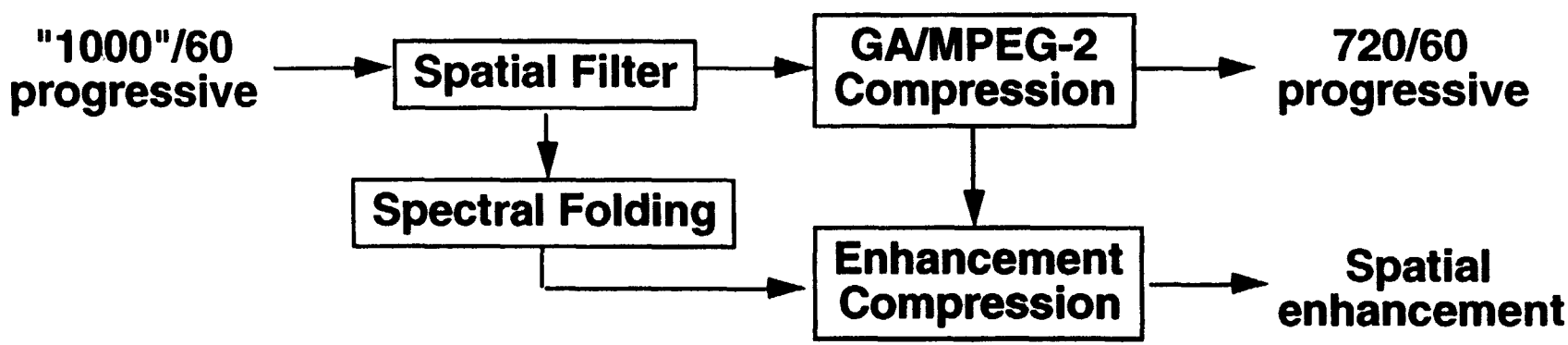
"1000"/30 Enhancement



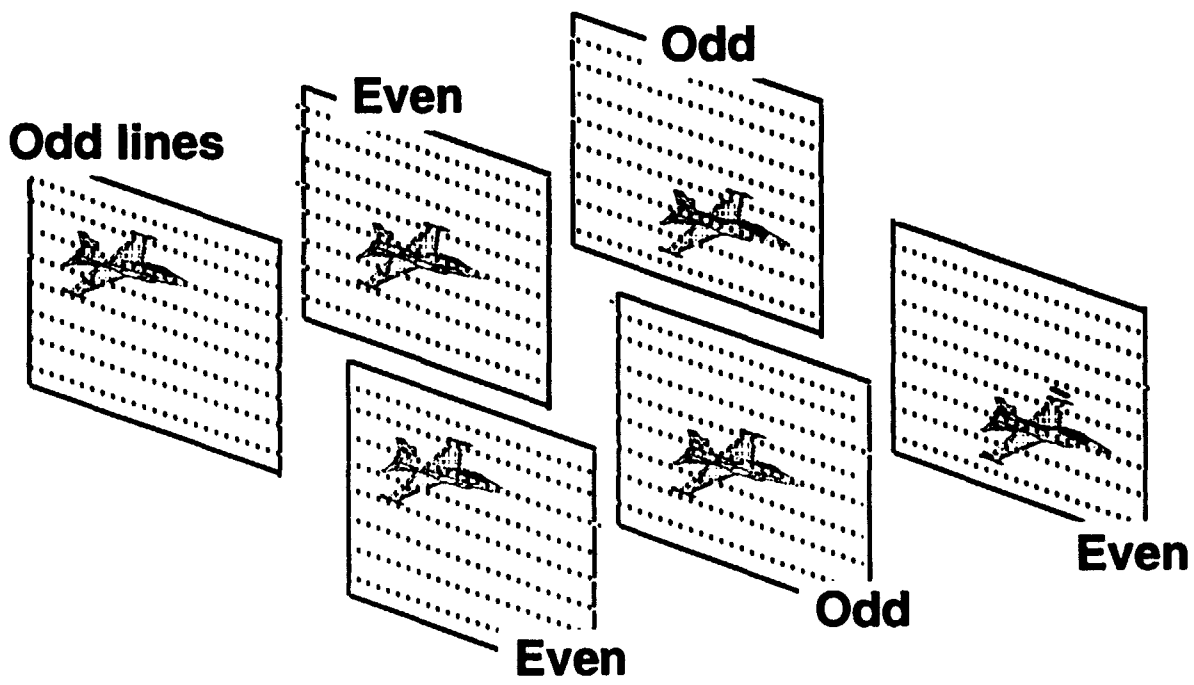


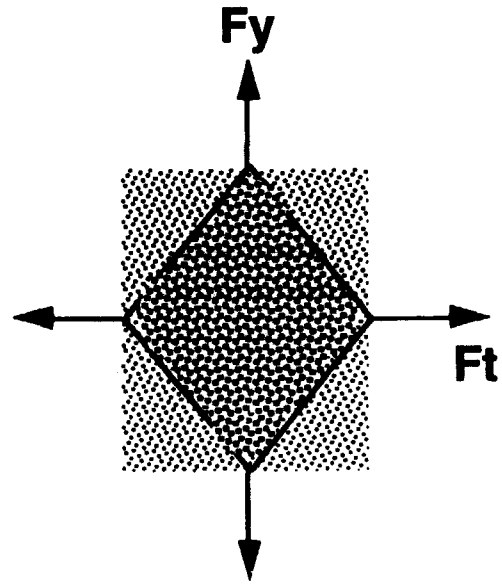
720/60 Enhancement

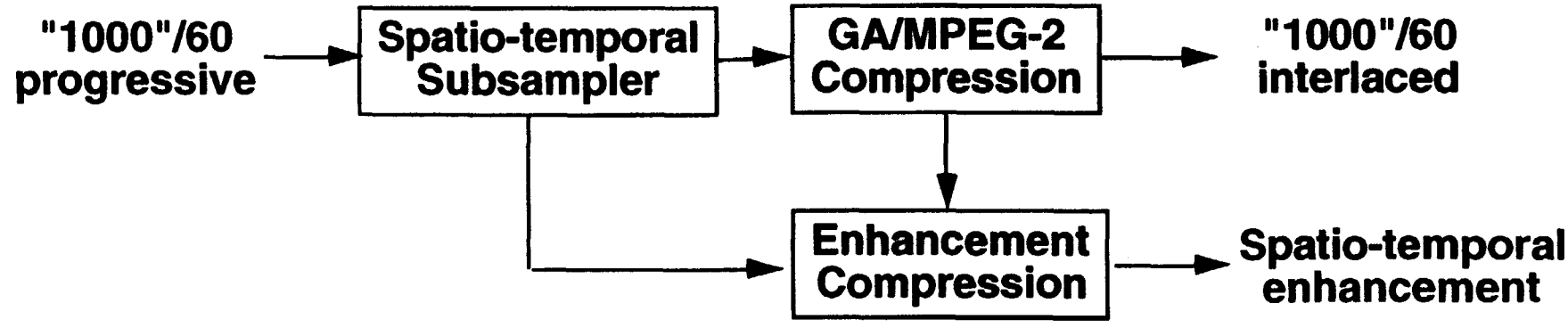




"1000"/60 Enhancement







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Packet-Level Extensibility

- The GA system has inherent packet-level extensibility
- All packets have a PID header/descriptor
- New Service IDs for enhancement data are readily added and multiplexed into the packet stream

- Service ID header/descriptor eliminates backward compatibility problems - receivers ignore service types that they cannot process

Summary

Interoperability Summary

- **The GA System has been designed with a heavy emphasis on interoperability**
- **Within the context of a transmission standard, we immediately create a high degree of interoperability among very different industries**
- **The Grand Alliance approach is to provide flexibility that simultaneously meets different needs and *facilitates* interoperability, rather than attempting to force a particular approach on a given application**
- **This flexible approach will allow natural economic forces to promote the migration to modes with the greatest interoperability**